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A COMPARISON OF SITE CURVES FOR DOUGLAS-FIR

by

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INTRODUCTION

The use of the height-age relationship for determination of site quality has long been generally accepted for Douglas-fir in the Pacific Northwest. It provides the basis of site classification in yield studies and in management planning.

There are numerous published height-age curves for the species, both in North America and in Europe (see, for example, the listing given by Smith et al. 1960).[1] These exhibit a diversity of shapes, presumably reflecting both differences in method of preparation and in the site and stand conditions from which the original data were taken.

The site index curves in general use in the Pacific Northwest are those given by McArdle et al. (1961). These are proportional curves, originally prepared in the 1920's from single determinations of average height and age for a sample of natural stands thought to represent comparable average site quality over the range of ages.

Curves prepared by these methods are subject to two main types of possible errors:

1. The shape of the average curve used as the basis of the system may be incorrect; this can result from unequal representation of sites in the different age classes in the sample.

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[1] Names and dates in parentheses refer to Literature Cited, p.7.

2. The common assumption that height-over-age curves are proportional for all sites may be incorrect; polymorphic (nonproportional) curves may be more suitable.

The shape of existing site curves may best be judged by comparison with height growth data obtained from remeasurements of permanent plots, or by comparison with height curves obtained from stem analyses. A number of such comparisons, though of limited scope, have been or can readily be made:

1. The University of British Columbia has done a considerable amount of stem analysis work at Haney, British Columbia. Results and comparisons with existing curves have been reported by Heger,[2] Smith (1962), and Smith and Walters (1964).

2. The British Columbia Forest Service (1953, pp. 41-42) has published an average height curve based upon records from remeasured permanent plots.

3. Warrack (1959) has prepared an average height curve based on stem analyses made at Cowichan Lake, Vancouver Island, British Columbia.

4. Spurr (1952) prepared "natural" height-age curves for Douglas-fir, based on the data available at that time from remeasured permanent plots of the Pacific Northwest Forest and Range Experiment Station in Washington and Oregon. Most of these data were from stands over 45 years of age.

All the above curves exhibit a generally similar pattern of divergence from the standard curves (McArdle et al. 1961); lower heights at the younger ages suggest that the latter may underestimate site quality of young stands. Polymorphic curves based on floristic site types, prepared by Spilsbury and Smith (1947) and by Eis (1962), also appear to indicate the same general pattern.

It is interesting to note that Spurr's curves are very similar in shape to the average height-age curve of Munger (1911), possibly the first such curve ever published for Douglas-fir in the Pacific Northwest (fig. 1), and to Hanzlik's 1914 curves.

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[2] Heger, L. A comparison of conventional and natural height-age curves for Douglas-fir. 71 pp. 1959. (Unpublished master's thesis on file at Univ. Brit. Columbia, Vancouver.)

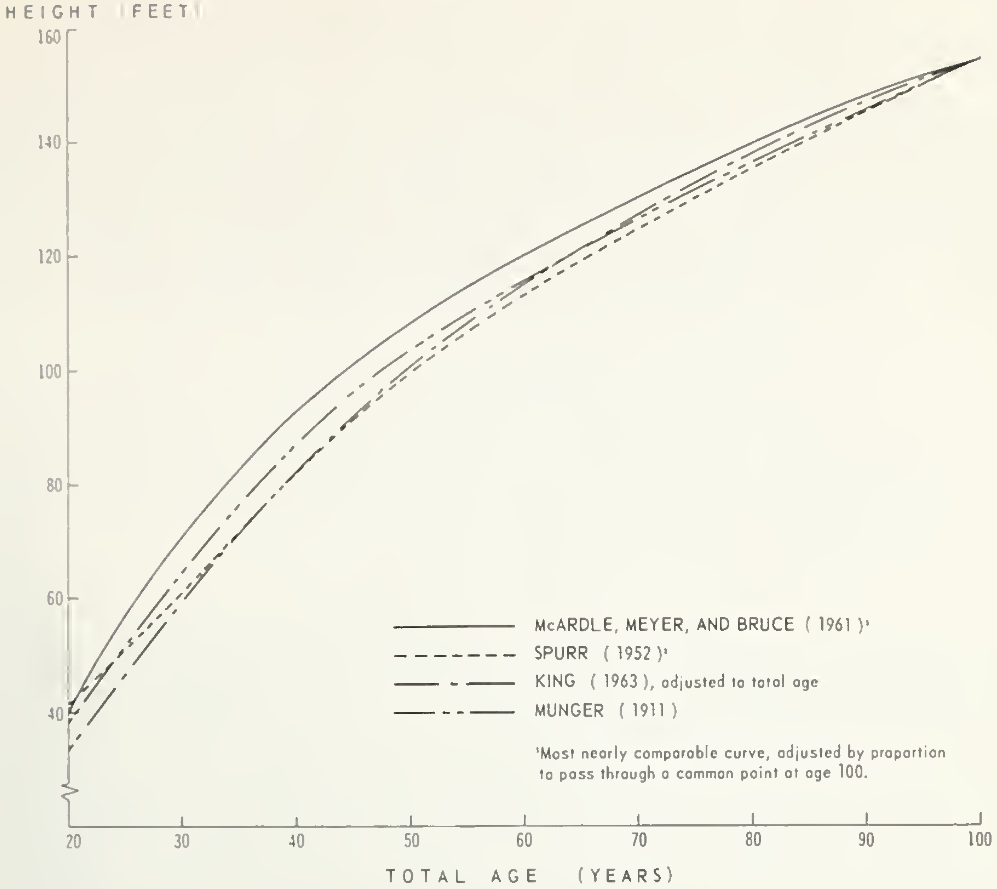

Figure 1.--Comparison of shapes of some Douglas-fir height-age curves for Washington and Oregon.

Recently, James King of Weyerhaeuser Co. has prepared a new set of site curves[3/] for second-growth Douglas-fir, based on measurements of internode length and age at breast height of the largest 20 percent (by diameter) of trees from 50-tree samples. When compared with McArdle's curves (after adjustment to a comparable age basis), these exhibit a

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[3/] King, J. E. Preliminary site index tables for Douglas-fir. 20 pp. 1963. (Unpublished report on file at Weyerhaeuser Co., Forestry Research Center, Centralia, Wash.)

King, J. E. Site index curves for Douglas-fir in the Pacific Northwest. (In preparation for publication, Weyerhaeuser Co., Forestry Research Center, Centralia, Wash.)

pattern of divergence similar to the other curves cited, even more pronounced in very young stands.

McArdle[4] has recorded the procedure used in constructing his site curves. Of the original data, a portion was discarded in order to get what he considered comparable average site quality in the different age classes. Of the data used in preparing the final curves, relatively little was from stands under 40 years of age. Hence, the hypothesis that the shape of the published curves may not be correct for young stands appears plausible.

THE COMPARISON

In connection with a study of gross yield of Douglas-fir,[5] a comparison was made of the standard curves with King's preliminary curves, using data available from remeasured permanent plots in stands under rotation age.

Where estimates of site index have been made at successive remeasurements of the same plot, one would expect--if the site curves used correctly represent the average curve of height growth--that estimated site index would be unrelated to age. From figure 1, it is apparent that, if the King curves are correct, successive estimates of site index made on the same plot with the standard curves would tend to rise with increasing age. Conversely, if the older curves are correct, estimates based on the King curves would tend to decrease as age increased. Since differences between curves are most pronounced in the younger ages, the relationship of site index to age might be expected to approximate linearity when logarithm of age is taken as the independent variable.

Data used in the comparison consisted of successive measurements of permanent plots located in well-stocked, unmanaged Douglas-fir stands for which there were available four or more successive estimates of site index at intervals of 5 years or more. These plots consisted of the 31 listed by Williamson (1963), together with 6 control plots from thinning studies. Height and site index values were taken from applicable Forest Service progress reports.

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[4] McArdle, R. E. Site index curves by anamorphosis. (Memorandum dated Feb. 26, 1926, on file at the Pacific Northwest Forest and Range Exp. Sta., Portland, Oreg.)

[5] Curtis, Robert O. A study of gross yield in Douglas-fir. 152 pp. 1965. (Unpublished Ph.D. thesis on file at Univ. Wash., Seattle.)

Values used for SI_{50} (site index estimated by King's curves) were obtained by applying the King curves to the mean height of dominants and codominants given in the progress reports. In these well-stocked stands, the 20 percent of all stems with largest diameter usually consisted of dominants and larger codominants. Hence, use of mean height of dominants and codominants results in a slight but consistent underestimate of site index as defined by King. Since interest was in relative change rather than absolute value, this bias was not considered serious for purposes of the desired comparison.

A consistent relationship of successive estimates of site index on the same plot to stand age (or its logarithm) would indicate that the site curves used do not correctly represent the course of height growth. In other words, the site curves should be considered unsatisfactory if the value of b is significantly different from zero in the equation:

$$Y_{ij} = u + P_i + bX_{ij} + e_{ij}$$

where Y_{ij} is estimated site index of plot i at measurement j; u is mean site index for all plots and ages; P_i is deviation of mean site index of plot i from the overall mean u; X_{ij} is logarithm of age of plot i at measurement j; e is an independent normal random variable.

The hypothesis that the average value of b for these 37 plots is zero was tested by covariance analysis for two sets of values:

1. Values of SI_{100} (site index by McArdle's curves) and logarithms of corresponding ages.

2. Values of SI_{50} and logarithms of corresponding ages.

Results obtained were:

1. For McArdle's curves (SI_{100})

F = 78.5 with degrees of freedom 1, 201

where $F_{.01} = 6.76$

2. For the King curves (SI_{50})

F = 3.46 with degrees of freedom 1, 201

where $F_{.05} = 3.89$

Thus, estimates of site index obtained by use of McArdle's curves were found to be significantly related to logarithm of age, whereas those obtained with King's curves were not.

For each individual plot, regressions of SI_{100} and SI_{50} on logarithm of age were calculated. For SI_{100}, 16 of the 37 regressions had slopes significantly different from zero, with 13 positive and 3 negative. For SI_{50}, 14 had slopes significantly different from zero, with 7 positive and 7 negative.

DISCUSSION AND CONCLUSIONS

For these 37 plots, the King curves represent the observed pattern of height growth better than do the standard curves. However, it is clear that the height-age curve for an individual plot may differ considerably from either the King or standard curves.

The comparison covers a rather restricted range of ages, with relatively little data from stands less than 45 years old. The age range 20 to 50 years, in turn, is that in which King's curves diverge most radically from McArdle's. Consequently, the analysis does not necessarily demonstrate that the King curves are superior. It does show that--within the age range of the majority of these plots--average observed height growth diverges from McArdle's curves in a manner consistent with both King's curves and the other curves discussed earlier.[6] If, as this suggests, the divergence extends down into younger ages, then it follows that the standard curves overestimate height growth and underestimate site index of younger stands. The resulting errors in estimation of site index could be greater than for the older stands used in this comparison.

From figure 1, it is evident that possible differences in curve shape above about 50 years of age are much less important; even if real, they are not likely to introduce large errors in site classification.

If the standard curves do consistently underestimate site index of young stands, then it also follows that the curves of normal basal area and normal yield (McArdle et al. 1961)--being based on classification by these site curves--contain corresponding distortions in the same age range. Since the age range 20 to 50 years is also the period of most rapid cubic-volume increment, estimates of cumulative gross yield could also be seriously affected.

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[6] The data used in this analysis included much of that used by Spurr (1952), plus additional data accumulated since. Hence, the result obtained is not independent of Spurr's work.

With the increasing importance of young Douglas-fir stands and growing interest in their management and yields, further comparisons of the standard and alternative site curves appear desirable. Emphasis should be on stands under 50 years of age. Meanwhile, King's new curves appear promising as a prospective replacement for the older curves.

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